

Reproductive patterns and seasonal occurrence of the Sea Hare *Aplysia brasiliana* Rang (Gastropoda, Opisthobranchia) at South Padre Island, Texas

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Abstract. Monthly collections of *Aplysia brasiliana* Rang were made at South Padre Island, Texas over an 18 month period. Seasonal changes in distribution of weight classes support the existence of a maximum life cycle of approximately 1 year. Large numbers of juveniles in spring collections are produced by the reproductive activities of overwintering adults or possibly recruitment of larvae from other areas. The spring recruitment is followed by the disappearance from the population by large overwintering specimens. Spring juveniles increase in size and weight by late summer. Early fall collections yielded no specimens. A minor period of secondary recruitment can occur during late fall or early winter. Winter collections, when successful, yielded reduced numbers of large adults.

A number of investigations conducted on naturally occurring aplysioid populations have centered upon duration of life cycles, seasonal changes in size or weight, reproductive activities, and recruitment into the population by recently metamorphosed juveniles (Miller, 1960; Carefoot, 1967; Usuki, 1970; Audesirk, 1979; Sarver, 1979; Gev *et al.*, 1984). Following a review of these studies, Carefoot (1987) concluded that, while considerable variation does exist in some species, most sea hares do, in fact, exhibit an annual life cycle.

This conclusion is consistent with current information for the sea hare *Aplysia brasiliana*, which is common to the Gulf of Mexico (Strenth and Blankenship, 1978a). For Florida populations of *A. brasiliana*, both Krakauer (1969) and Hamilton *et al.* (1982) concluded that this species exhibits a life cycle of approximately one year. Krakauer's (1969) conclusions relative to *A. brasiliana* (as *A. willcoxi* Heilprin) were, however, based upon only a one year series of collections of relatively small sample sizes. The study by Hamilton *et al.* (1982) was based upon large sample sizes but unfortunately was limited to the months of March through June. Krakauer (1969) also characterized the life cycle of *A. brasiliana* in Florida as having "two waves of settling" with a major "spawning period" in late March and early April. Following several years of preliminary field work, this study was undertaken in an effort to clarify the life cycle of *A. brasiliana*.

METHODS

Collections were made on a continuous monthly basis

in the south Laguna Madre at South Padre Island, Texas, at depths of < 1 m, from July, 1977 through December, 1978. All known habitats of *Aplysia brasiliana* were established during preliminary field work in 1975 and 1976. While each of these habitats was surveyed during each trip, collection techniques and success varied with the season. Winter and spring collections were most productive during early morning low tides. These low tides trapped nocturnally active specimens in shallow grass flats which are common along the western coastal margin of the island. Recently metamorphosed juveniles were collected in the spring from artificial habitats of broken concrete, brick and stone, which had been deposited near the east abutment of the old causeway. During summer months, swimming specimens were collected with dip nets at night near the lights of fishing piers located along the western side of South Padre Island. Specimens were also found on rocks of the boat slip at the Coast Guard Station and the channel side of the north jetty. Following collection, specimens were weighed to the nearest gram.

RESULTS AND DISCUSSION

DURATION OF LIFE CYCLE

The results (Fig. 1) of this study support the existence of a maximum life cycle of approximately 1 year for *Aplysia brasiliana* at South Padre Island, Texas. Summer collections, such as those of 1977, were generally characterized by the presence of specimens in the 50 to 300 gm weight range. These animals increased in size and weight during the late fall and winter. By March of the following spring (Fig. 1),

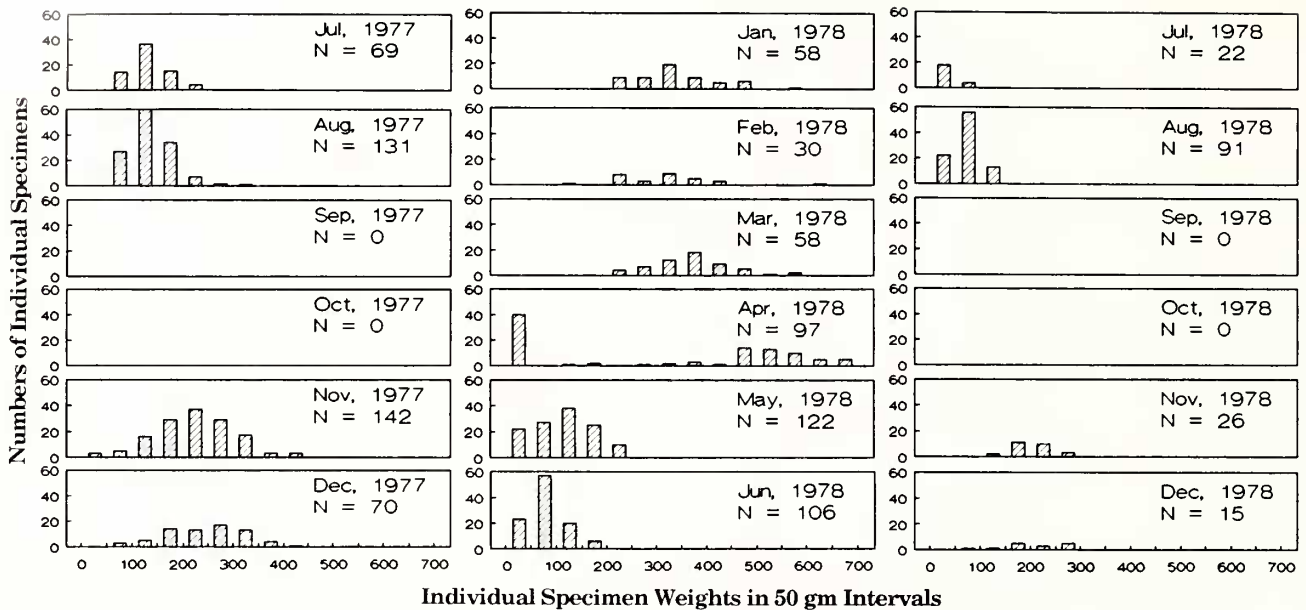


Fig. 1. Numbers of specimens of *Aplysia brasiliana* in each 50 gm weight class of monthly collections at South Padre Island, Texas from July, 1977 through December, 1978.

the population was characterized by specimens in the 250 - 600 gm range. The marked appearance of large numbers of recently recruited juveniles in the April, 1978 collection, as well as moderate numbers of large specimens in the 450 - 700 gm size, clearly revealed the overlap of generations. These very large specimens were absent from the population by the following month. Similar life cycle lengths have been reported by Carefoot (1967) for *A. punctata* Cuvier, by Audesirk (1979) for *A. californica* Cooper, and by Usuki (1970) for *A. kurodai* (Baba) and *A. juliana* Quoy and Gaimard.

RECRUITMENT

The results of this study (Fig. 1) confirm the presence of a major period of recruitment of recently metamorphosed juveniles during the spring of the year. The April, 1978 collection clearly revealed the marked appearance of large numbers of specimens in the 1 - 50 gm weight class. The presence of specimens weighing less than 50 gm in the collections of June, July and August of 1978 initially suggested a continuous 5 month period of recruitment. This does not, however, appear to be the case. Based upon field observations made during 1975, 1976 and 1977, the spring recruitment of 1978 appeared unusually large. Hundreds of swimming specimens were observed in May. Small to medium sized specimens were very abundant on the rocks of the jetty and Coast Guard Station.

A marked decline in numbers of specimens was evident by early summer and, despite an extensive collecting effort, the July collection resulted in only 22 specimens. It appears that the unusually large spring recruitment of 1978

was followed by a mid-summer crash in the population. While the June, July and August collections were characterized by specimens under 50 gm, there were no specimens in the 1 - 10 gm range which had characterized the April collection. The small specimens present in the June, July and August collections of 1978 were therefore considered to be spring recruits which were unable to increase in size due to competition, rather than recent recruits to the population. Collections made during the summer of 1977 (Fig. 1) as well as those of 1976, appear to support this conclusion. These collections were characterized by specimens in the 50 - 300 gm range, as well as the absence of smaller specimens in the 1 - 50 gm range. The summer collections of 1977 are therefore considered typical for this species.

The presence of one 12 gm specimen as well as several others weighing less than 50 gm in the November, 1977 collection (Fig. 1) supports the existence of a minor period of secondary recruitment during the late fall or early winter. The life cycle of *Aplysia brasiliana* at South Padre Island appears to be characterized by the presence of a major period of spring recruitment followed by a very minor period of secondary recruitment during late fall or early winter. Usuki (1970) reported similar findings for *A. kurodai* in the Sea of Japan.

Aplysia brasiliana appears to exhibit a relatively high reproductive potential during much of its life cycle. Upon capture, specimens were observed to engage readily in copulatory and egg laying activities throughout most of the year. Despite this fact, recruitment is clearly not a continual process. Recent life history studies (e.g. Sarver, 1979; Gev *et al.*, 1984) have established the relationship of the seasonal abundance

of select algal species with the timing of metamorphosis and subsequent recruitment of juveniles into naturally occurring populations of various aplysiid species (see Carefoot, 1987, for review).

Mature veliger larvae of *Aplysia brasiliana* readily metamorphose in the presence of the red alga *Callithamnion* and, to a lesser degree, *Polysiphonia* (Strength and Blankenship, 1978b). While *Callithamnion* can be found throughout most of the year (Sorensen, 1979), it reaches its maximum abundance at South Padre Island during March (Penn, 1974). This seasonal abundance of *Callithamnion* just precedes the major period of recruitment of juvenile *A. brasiliana* into the population in April. While many additional environmental factors should be considered, it appears possible that this seasonal peak of *Callithamnion* could be a major contributing factor in the timing of the spring recruitment of juvenile *A. brasiliana* at South Padre Island, Texas.

SEASONAL OCCURRENCE

The disappearance of specimens from otherwise normally occupied habitats during the months of September and October (Fig. 1) appears to be a normal aspect of the life cycle of *Aplysia brasiliana* at South Padre Island. Krakauer (1969) also failed to collect specimens of this species in Florida during this same time period. Studies on other aplysiids have reported similar decreases in numbers of specimens during the fall of the year. Audesirk (1979:413) reported a "nearly total disappearance of animals" for *A. californica* during October, November and December. Gev *et al.* (1984:69) reported that "The *Aplysia* season ends in September" for *A. depilans* Gmelin and *A. fasciata* Poiret along the Mediterranean coast of Israel. Both Audesirk (1979) and Gev *et al.* (1984) related this noticeable drop in numbers of specimens during the fall of the year to the decline of one year class, which in turn is replaced by the succeeding generation.

Results obtained during the course of this study do not support the above premise as it relates to *Aplysia brasiliana* at South Padre Island. While some minor recruitment could occur during November or December following the absence of collectable fall specimens, there is no major shift in modal weight class during the fall such as that observed for the month of April, 1978 (Fig. 1). In addition, average weights of specimens increased from August to November during both years. The average weight during 1977 increased from 139 gm (N = 131) in August to 220 gm (N = 142) in November. During 1978, the average weight increased from 67 gm (N = 91) in August to 206 gm (N = 26) in November. The demonstrated presence of continual weight increase in specimens from August to November, as well as the absence of large numbers of recently recruited juveniles in the early winter collections, serve to support the existence of a

standing population of *A. brasiliana* which is characterized by slight to moderate increases in size of individual specimens rather than a population undergoing decline and replacement.

A suitable explanation to account for the location of specimens during September and October does not appear forthcoming from observations made during the course of this study. While discounting reproductive migration in general, Carefoot (1987:204) states that the theory of feeding migrations is often "attractive in that it accounts for seasonal gaps in abundance." Neither the theory of reproductive migration nor that of feeding migration appear to provide a feasible explanation (see below) to account for the disappearance of *Aplysia brasiliana* at South Padre Island during the early fall of the year.

Aplysia brasiliana is a known burrower (Aspey and Blankenship, 1976). Individual specimens could be undergoing continual or prolonged intermittent periods of burrowing in the soft substratum of the south Laguna Madre during September and October. It should be emphasized that this hypothesis is conjectural and not supported by field work. It should be noted, however, that decreased foraging activities by burrowed *A. brasiliana* during September and October could possibly facilitate a rebound in the standing crop of *Callithamnion*, which in turn could account for the secondary period of recruitment during late fall or early winter.

MIGRATION

In his review of migration theory as it relates to life cycles of aplysiids, Carefoot (1987:203) states that "This theory of migration has fallen into disfavour from lack of supporting evidence". While individual specimens were observed to exhibit localized movements in association with foraging behavior, the current study provides no support for the migration theory as it relates to *Aplysia brasiliana* at South Padre Island, Texas. This could be due in part to the somewhat confined nature of the south Laguna Madre as well as the presence in the lagoon of both adult food (*Laurencia* and *Gracilaria*) as well as metamorphosing substrata (*Callithamnion* and *Polysiphonia*) for developing larvae. Juveniles and adults were collected from the exact same habitats during different times of the year.

While specimens of *Aplysia brasiliana* are found occasionally beached on the Gulf of Mexico side of the island, the nature of the offshore substrate does not appear to favor the attachment of suitable benthic marine algae. Consequently, the immediate offshore environment of South Padre Island appears to offer little if any favorable habitat for completion of all or part of the life cycle of *A. brasiliana*. While not surveyed in this study, deeper off-shore reefs are known habitats (Tunnell and Chaney, 1970) for *A. brasiliana* and could provide for variations in life cycles not observed during the course of this study.

CONCLUSIONS

The results of this study are consistent with and support the conclusions of both Krakauer (1969) and Hamilton *et al.* (1982) that the maximum length of the life cycle of *Aplysia brasiliana* is approximately one year. This species exhibits a major period of recruitment during the spring followed by a marked loss of large overwintering specimens from the population. A minor period of secondary recruitment can occur during late fall or early winter. The reason for the absence of collectable specimens during the early fall currently remains obscure.

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